

Microgrid Control Technology Based on NeuralLike P Systems with State Values

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Abstract. By utilizing the mobile energy storage characteristics and random dispersion of electric vehicles, it is coordinated with the wind power storage unit to optimize the economic and reliable operation of the system. In this paper, the integrated microgrid of wind, photovoltaic, energy storage and electric vehicle is studied. Under the premise of ensuring the safety and stability of the system, the control goal is to meet the needs of electric vehicles users as much as possible and to maximize the utilization ratio of new energy. The operation control strategies of power battery under disordered charging and orderly charging/discharging are considered respectively. Subsequently, the operation model of wind turbine generation and electric vehicles orderly charging/discharging is established by using the neural-like P system with "state value", and the operation modes of each unit are obtained according to the operation of microgrid. Finally, the effects of disordered charging and orderly charging/discharging of electric vehicles on the safe and stable operation of the microgrid system are compared by simulation experiments.

1. Introduction

The characteristics of mobile energy storage and the randomness of charging load of electric vehicle (EVS) can be coordinated with the intermittency of renewable energy. Connecting photovoltaic (Pv)/wind turbine (Wt)/es and EV directly to the power grid can reduce the cost of ES and the number of charges and discharges.[1-2]. The neural-like P system is a computational model which abstracted from the characteristics of the way in which information is communicated among neurons in the brain central nervous system[3]. This neural P system is used to solve the very common and classical NP problem, the SAT problem, in linear time [4]. Wang.T [5], a neural P system with "state value" was proposed, which was successfully applied to the power coordination control in WT/PV/ES microgrid.

In this paper, the characteristics of neural network-like P system in microgrid coordinated control and the influence of electric vehicle on voltage fluctuation are studied. At the same time, the common coupling point (PCC) of grid-connected microgrid takes into account the mode of disordered charging and ordered charging and discharging. Under the premise of ensuring the safety and stability of the system, we should meet the needs of electric vehicle users as much as possible and maximize the utilization of new energy.

2. Operation Control Strategy of Microgrid

A microgrid composed of PV, WT, ES, EVs and loads is presented in fig.1 . The system bus is an AC connection, and connected to the distribution network by grid-connected switches.

In the EVs disordered charging mode. When the PCC voltage fluctuates within the normal range, the WT and PV units generating sufficient power to supply the conventional load and the EVs and the ES. If the WT and PV units generating less energy and the SOC of ES is higher, then the WT/PV/ES units will supply power to the load together. If the PCC voltage is lower than the lowest allowable fluctuation, the WT/PV units operate in MPPT mode and the battery is discharged as much as possible. When the PCC voltage is too high, the battery is charged and the load is applied to the maximum. If there is still excess power, the renewable energy generation power can be limited. EVs have charging and discharging characteristics in an ordered charge and discharge mode. When the PCC voltage fluctuates within the allowable range, the WT/PV is usually in MPPT mode. At this time, the electric vehicle should be arranged to charge the grid as much as possible, and the battery should be charged and discharged according to the state of the SOC and the load demand at this time. When the PCC voltage is lower than the minimum value of the allowable fluctuation, the WT unit operates in the MPPT mode, and the battery and the EVs are discharged. If the PCC voltage is too high, the EVs is charging, and the battery is charged according to the SOC level.

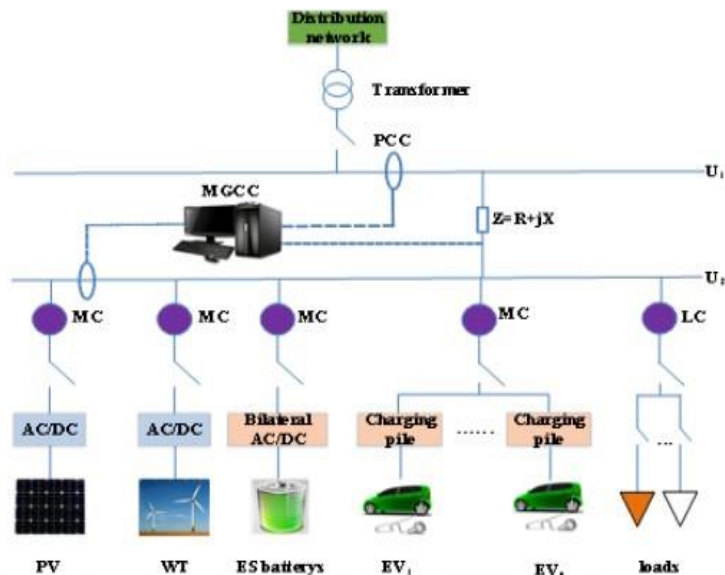


Fig. 1. Topology of a WT/PV/ES and EV integration microgrid

3. SVNPS-Based Models for Microgrid Units

Based on the basic neural-like P system [4], a kind of neural-like P system with "state value" (SVNPS) was proposed in [5]. This kind of P system obtained different state values by comparing the objects in the neuron with its threshold value and converted the system to a different pattern and the detailed definition of structure and operation process can be referred to in [5].

According to the definition of SVNPS and the operation control strategy in section.2, the SVNPS models of the WT unit and the EVs unit are established.

3.1 The WT unit Model

In general, the WT unit is work in MPPT mode. Only when the voltage of PCC is too higher and SOC levels of the ES and EVs are greater than 0.9, can it be switched to the mode of limited power output. Based on this principle, an SVNPS model for the WT unit is established as shown in fig. 2.

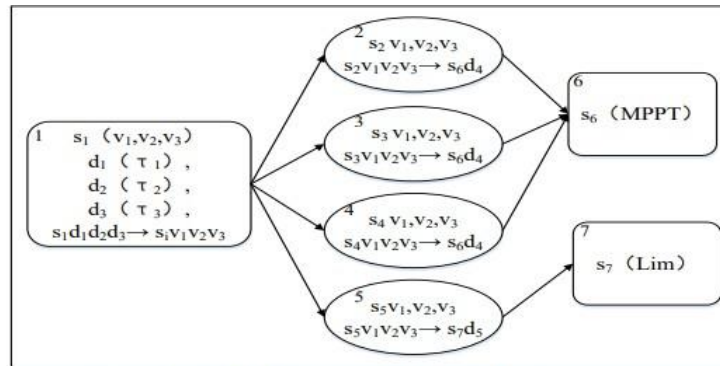


Fig. 2 An SVNPS model for the WT unit

An SVNPS model for a WT unit is a construct:

$$\Pi_1 = (\{O, T, Q, \sigma_1, \dots, \sigma_7, \delta, \eta, syn, i_o\})$$

Where:

1. $O = \{d_1, d_2, d_3, d_4, d_5\}$, $O_{init} = \{d_1, d_2, d_3\}$, where d_l indicates the voltage (U_2) of PCC, d_2 indicates the SOC of batteries, d_3 indicates overall SOC of the EVs. $O_{fin} = \{d_4, d_5\}$, where d_4 and d_5 represents the MPPT mode and the limited mode, respectively.
2. $T = \{\tau_1, \tau_2, \tau_3\}$, where τ_1, τ_2 and τ_3 are the thresholds of d_1, d_2 and d_3 , respectively. They are the upper limits of voltage permissible fluctuation, the lower limits of VH and the upper limits of SOC of EV, respectively.
3. $Q = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7\}$, where s_l is the initial status, and $Q_I = \{s_2, s_3, s_4, s_5\}$ is the intermediate status, and $Q_F = \{s_6, s_7\}$ is the final status.
4. $\sigma_1, \dots, \sigma_7$ are seven neurons contained in this system and the states and rules within each neuron are given in Tab1.
5. δ is a mapping from $\{0,1\}^3$ to Q_I and be expressed as: $\delta(0, X, X) = s_2$, $\delta(X, 0, X) = s_3$, $\delta(X, X, 0) = s_4$, $\delta(1, 1, 1) = s_5$.
6. η is a mapping from $\{0,1\}^3$ to $Q_F \times O_{fin}$ and be expressed as: $\eta(0, X, X) = (s_6, d_4)$, $\eta(X, 0, X) = (s_6, d_4)$, $\eta(X, X, 0) = (s_6, d_4)$, $\eta(1, 1, 1) = (s_7, d_5)$.
7. $syn = \{(1, 2), (1, 3), (1, 4), (1, 5), (2, 6), (3, 6), (4, 6), (5, 7)\}$.
8. $i_o = \{6, 7\}$, where σ_6 and σ_7 are output neurons.

Tab 1 Neurons in SVNPS model for the WT unit

Neurons	Statuses	Rules
σ_1	s_1, s_i	$\sigma_1 = (\{s_1(v_1, v_2, v_3)\}, \{d_1(\tau_1), d_2(\tau_2), d_3(\tau_3)\}, s_1d_1d_2d_3 \rightarrow s_1v_1v_2v_3)$
σ_2	s_2, s_6	$\sigma_2 = (\{s_2(v_1, v_2, v_3)\}, s_2v_1v_2v_3 \rightarrow s_6d_4)$
σ_3	s_3, s_6	$\sigma_3 = (\{s_3(v_1, v_2, v_3)\}, s_3v_1v_2v_3 \rightarrow s_6d_4)$
σ_4	s_4, s_6	$\sigma_4 = (\{s_4(v_1, v_2, v_3)\}, s_4v_1v_2v_3 \rightarrow s_6d_4)$
σ_5	s_5, s_7	$\sigma_5 = (\{s_5(v_1, v_2, v_3)\}, s_5v_1v_2v_3 \rightarrow s_7d_5)$
σ_6	s_6	$\sigma_6 = (s_6, d_4, \{s_6d_4 \rightarrow s_6(d_4, out)\})$
σ_7	s_7	$\sigma_7 = (s_7, d_5, \{s_7d_5 \rightarrow s_7(d_5, out)\})$

The calculation process is as follows:

Step1: Calculate the state value. The $v(d_l)$ can be obtained by the voltage amplitude of U_2 , and

compared with τ_l . If $v(d_l) < \tau_l$ then $v_l = 0$ otherwise $v_l = 1$.

Step2:The intermediate state is selected. The rule $s_1d_1d_2d_3 \rightarrow s_l v_1 v_2 v_3$ occurs in the neuron σ_l , the system changes from the s_1 to $s_2 \dots s_5$, and the state value $v_3 v_2 v_1$ is derived from the neuron σ_l sent to the corresponding neuron.

Step3:Execution rules. When an intermediate neuron receives a state value, the rules within the neuron are fired, and the next state transition occurs, generating a new object for delivery to the next level of neurons.

Step4:Output. When the output neuron receives the object and executes the regular within the neuron then output the object, the system terminates.

3.2 The EV Unit Model

Under the order of charge and discharge, EV have two modes of charging and discharging. When the system power load is at a low(L) level, the EVs is arranged to charging. When the system is at the peak of the power load, the EV is discharging. Based on the above principles, the SVNPS model for the EVs under the orderly charging/discharging mode is established as shown in Fig. 3.

The SVNPS model for the EVs unit is expressed as follows:

$$\Pi_2 = (\{O, T, Q, \sigma_1, \dots, \sigma_9, \delta, \eta, syn, i_0\})$$

The structure of the system is similar to that of the WT unit system, the differences are described below.

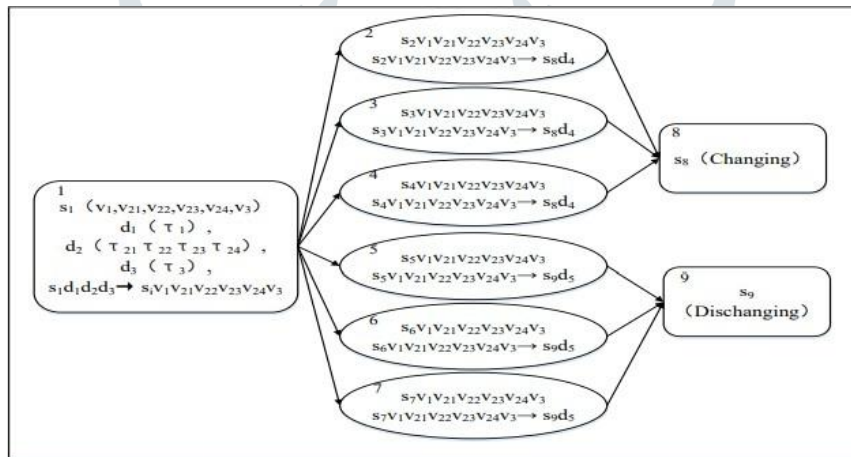


Fig 3. An SVNPS model for the EVs

Where:

1. $O = \{d_1, d_2, d_3, d_4, d_5\}$, $O_{fit} = \{d_4, d_5\}$, where d_4 indicates the charging mode of the EVs, d_5 indicates the discharging mode.
2. $T = \{\tau_1, \tau_{21}, \tau_{22}, \tau_{23}, \tau_{24}, \tau_3\}$, Where $\tau_{21}\tau_{22}\tau_{23}\tau_{24}$ is the threshold of the d_2 , which corresponding to the lower limit of the SOC of the ES at L, middle high(M), high(H) and VH level and corresponding to four state values $v_2 v_1 v_2 v_3 v_2 v_4$, respectively.
3. $Q = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9\}$ where s_1 is the initial status, and $Q_I = \{s_2, \dots, s_7\}$ is the intermediate status, and $Q_F = \{s_8, s_9\}$ is the final status.
4. Neurons $\sigma_1, \dots, \sigma_9$. The corresponding state are : $s_{2,3,4} \sim s_8$ and $s_{5,6,7} \sim s_9$, respectively.
5. δ, η are the mapping from $\{0,1\}^6$ to Q_I and $Q_F \times O_{fin}$, respectively.
6. $syn = \{(1, 2), (1, 3), (1, 4), (1, 5), (1, 6), (1, 7), (2, 8), (3, 8), (4, 8), (5, 9), (6, 9), (7, 9)\}$
7. $i_0 = \{8, 9\}$, where σ_8 and σ_9 are output neurons.

The calculation process of the system is similar to that of the wind power unit system.

4. Experimental Simulation and Result Analysis

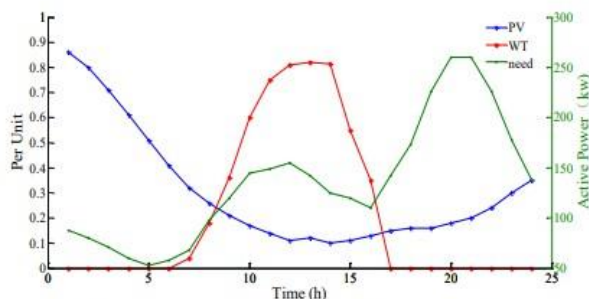


Fig. 4. Predicted output power of WT and PV and active power of loads

Considering 80 private cars in this paper. And the dispatching period is one day, which is divided into 24 hours to calculate separately. Microgrid system capacity configuration: PV (150KW), WT (150KW), storage (200KWh), load1 (50KWh), load2 (200KWh), EV (300KW). WT/PV and load curves are shown in Fig. 4.

4.1 The disordered charging of EVs

Fig. 5 shows the active power output of PV/WT/ES/EVs and load unit under disorderly charging mode. The SOC of ES and the fluctuation of PCC voltage are shown in Fig.6. From Fig.6, in the period of 0:00-3:00, WT is sufficient and the overall load of the system is small, and the WT unit supplies power to the load and battery. During the period of 4:00-6:00, the SOC of ES has reached the upper limit, and the voltage of PCC is too high. During the period from 7:00 to 14:00, the load of the system increases gradually. At this time, the WT and PV units supply power to the load at the same time. After 15:00, PV is gradually reduced to zero, but the load of electric vehicles is increasing. PV and WT supply system in MPPT mode, and storage battery SOC is very low.

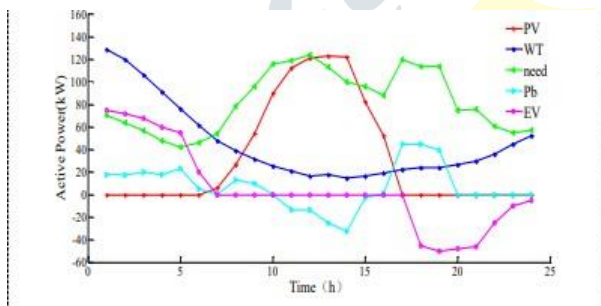


Fig.5 Output power of PV, WT, EVs, loads and battery in disordered charging mode

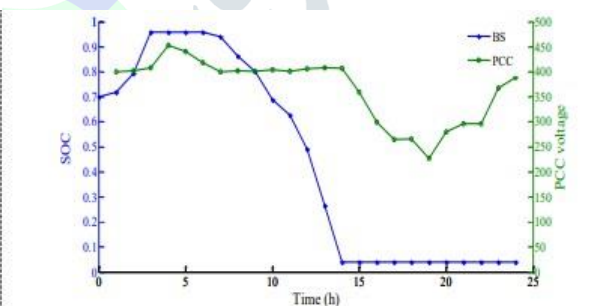


Fig.6 SOC change and PCC voltage fluctuation curve in disordered charging mode

4.2 The ordered charging/discharging of EVs

According to the microgrid control strategy of the EV under the orderly charging and discharging mode, the active power output of PV, WT, storage battery, EV and load units at each time are shown in Fig.7, and the voltage fluctuation curve of PCC and the SOC of the storage battery are shown in Fig. 8. Analysis of Fig.7-8 shows that in the 0:00-6:00 period, the WT is sufficient, the load is small, and the EV charges. SOC showed a downward trend when storage battery discharged. During the period from 7:00 to 10:00, WT is weakened, PV is enhanced, and EV load is zero. At this time, the WT,PV and ES units together supply power for the system load. During the 11:00-16:00 period, the new energy generation is insufficient to meet the system load, and the battery will change from charging to discharging. EV participates in dispatching, and its output is negative. After 20:00, the SOC of storage

battery reaches the minimum limit, which is supplied by EV and WT units to the load.

By comparing fig.5-8, the charging period is the low load valley and the discharging period is the peak load when the EVs enters the network by orderly charging and discharging mode. Contrasted to the disorderly charging mode of electric vehicle, the charging period plays a role of peak-cutting and valley-filling for the system load and effectively reduces the fluctuation of PCC voltage.

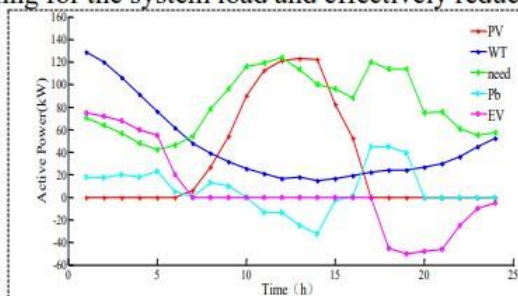


Fig.7 Output power of PV, WT, EVs, loads and battery in coordinated charging/discharging mode

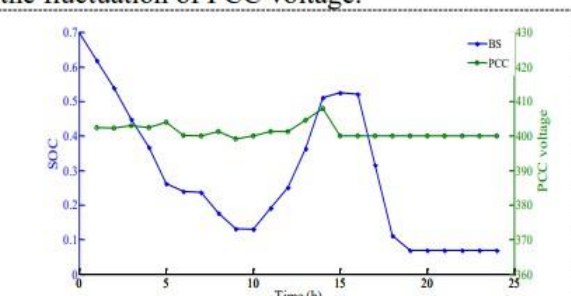


Fig.8 SOC change and PCC voltage fluctuation curve in coordinated charging/discharging mode

5. Conclusion

In this paper, the power coordination problem in microgrid with EVs is studied. Firstly, the operation control strategies in disordered charging and ordered charging/discharging modes are proposed, respectively. Then combined with the characteristics of the "state value" system, the operating models of WT and EVs in orderly charging/discharging are established respectively, verifying the feasibility of the membrane calculation for the power coordination of the microgrid. Finally, the effects of the disordered charging and the orderly charging/discharging on the power coordination of microgrid system are compared by simulated experiments.



References

- [1] Wang, X.F., Shao, C.C., Wang, X.L., et al. (2013) Survey of electric vehicle charging load and dispatch control strategies. Proceedings of the CSEE., 33(1): 1-10(in Chinese).
- [2] Xu, S.H., Li, J.L. (2013) Grid-connected/island operation control strategy for photovoltaic/battery Micro-grid. Proceedings of the CSEE., 33(34): 25-33(in Chinese).
- [3] Ionescu, M., P un, G., Yokomori, T., (2006) "Spiking neural P systems,"Fundam. Inf., vol. 71, no. 2, pp. 279-308, Jan.
- [4] Pazos, J., Rodr guez-Pat n, A., Silva, A., (2003)"Solving SAT in linear time with a neural-like membrane system," Lect. Notes Comput. Sci., vol. 2686, pp. 662 669, Jun.
- [5] Wang,T,Wang,J,Ming,J, (2018) Application of Neural-Like P Systems With State Values for Power Coordination of Photovoltaic-Battery Microgrids, IEEE Access.

